

Bighorn Sheep

OVERVIEW

Bighorn sheep (*Ovis canadensis*) belong to the cloven-hoofed Bovidae family, which includes bison, antelope, and wild and domestic cattle, sheep, goats, and water buffalo. The ancestors of this species crossed the Bering Land Bridge from Asia to North America during the Pleistocene Ice Age. They gradually extended their range through the Rocky Mountains in Canada and as far south as Mexico. Today, Asian and North American sheep differ in external appearance, adaptations to climate, and habitat preference (Geist 1971).

The Rocky Mountain bighorn sheep (*O. c. canadensis*) found in Greater Yellowstone is one of several currently recognized subspecies. Other subspecies commonly known as Desert bighorn sheep, include *O. c. californiana*, which is currently listed as an endangered species. Dall's sheep (*O. dalli*) are a distinct North American mountain sheep occurring in Alaska and northwestern Canada. Stone's sheep (*O. d. stonei*) are a subspecies of Dall's sheep.

Physical Description

At birth, bighorn sheep weigh 5.9–9.9 lbs (2.7–4.5 kg) and can reach 174–319 lbs (79–145 kg) as adult males (rams) and 130 lbs (59 kg) as adult females (ewes). Adult rams average 2.7–3.7 feet (813–1118 mm) at the shoulder; adult ewes average 2.5–2.9 feet (760–910 mm). Bighorn sheep have a brown to grayish-brown coat with large white-cream rump patch, muzzle, and back of legs. A dark stripe of hair runs from the top of the rump to the tip of the tail. The spring molt lasts 1–2 months (Krausman and Bowyer 2004).

The horns of a bighorn ram are its most striking feature, and are the largest of any ruminant in proportion to body size. Made of keratin, the horns grow under the preceding year's growth and over a hollow bone core which is an extension of the frontal bone. The annual growth rings can be used to determine age, though the small, crowded rings of ewes can be difficult to count. Horn growth is greatest during the summer and early in life. Female horns grow very little after 4–5 years, most likely due to reproductive costs. Although yearling ram horns are close in size to those of ewes, an adult rams' horns can make up 8–12% of his total body weight (Geist 1966). Rams experience rapid horn growth from 3.5 to 8 years, when approximately 1/3 of their weight gained is in the horns. Horn size functions as a visual indicator of dominance and rank, which affects social relationships within herds. Breeding superiority and dominance are correlated with horn size and estrous ewes prefer rams with large horns (Fitzsimmons et al 1995).

Older ram horns may be “broomed” or broken at the horn tip, which can take off 1–2 years of growth. Ram skulls have two layers of bone above the brain that function as a shock absorber, an adaptation for the collision of head-on fighting that is used to establish dominance between rams of equal horn size (Krausman and Boyer 2003).

Distribution and Abundance

North America

Rocky Mountain bighorn sheep are native to the western United States and historically ranged from the Canadian Rockies through northern New Mexico. Bighorn sheep populations declined significantly after the arrival of Europeans because of competition with livestock, introduction of disease, unregulated hunting, and loss of habitat. The remaining indigenous sheep populations are often isolated and non-migratory because of habitat fragmentation. Populations of less than 100 animals are especially vulnerable to extinction (Singer and Gudorf 1999). Reintroductions and habitat protection are restoring bighorn populations to some of their historical ranges.

Bighorn Canyon National Recreation Area

Bighorn sheep are the dominant ungulate whose remains are associated with human artifacts dating from the middle Holocene found in a rockshelter located at 6,000–7,000 feet (1,829 to 2,134 m) on East Pryor Mountain. The site, known as Big Lip, was apparently used as a hunting and butchering site for bighorn sheep (National Research Council 2002). Wild sheep were extirpated from the area in the 1800s, but between 1971 and 1974, Montana Fish, Wildlife and Parks translocated 77 sheep from an Idaho herd to the Pryor Mountains west of Bighorn Canyon. Although no sheep remain in the highest reaches of the Pryors today, remnants of that herd moved east to occupy range along Bighorn Canyon. They were apparently joined there by remnants of a herd of 39 sheep that had been translocated in 1973 by the Wyoming Game and Fish Department (WGFD) from Whiskey Mountain, Wyoming into the head of Devil Canyon, east 15–20 km east of Bighorn Canyon (Singer and Gudorf 1999). Few sheep remained in Devil Canyon from the 1973 transplant, but translocations made in 2004 and 2006 brought the size of the Devil Canyon herd to more than 100.

The Bighorn Canyon sheep population grew to 211 in 1993–1994, but declined to approximately 125 in 1995–1996, primarily because of disease (Schoenecker 2004).

The current population is approximately 150-200. The Bighorn Canyon herd uses much the same range near the edge of Bighorn Canyon year-round, with some dispersal northward during the winter. Their range, which roughly extends north to south from Yellowtail Dam to Crooked Creek and east to west from Devil Canyon to the Big Coulee drainage, includes land managed by the National Park Service, the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM), and private land (Singer and Gudorf 1999). Devil Canyon Overlook is the core use area for both rams and ewes, but rams travel longer distance, leaving the herd in March for higher elevations in the Pryor Mountains until about October, when they return for the rut (Schoenecker 2004). Lambing occurs in May on the steepest slopes.

Yellowstone National Park

Historical accounts suggest that bighorn sheep were more abundant in the area before Yellowstone National Park (YNP) was established in 1872 than at present. Hunting and other human influences, such as disease transmitted from domestic sheep, may have eliminated resident populations north of the park and migratory groups that summered in the park (National Research Council 2002). Since the first winter counts were recorded for Mount Everts in the 1890s, population estimates have fluctuated markedly between 100 and 500. Today bighorn sheep are found on Yellowstone's northern range, where they exist in 10–13 bands that likely constitute a metapopulation which experiences periodic movements and gene flow by rams between the groups. In the winter of 1981–1982, after the sheep count reached a recorded high of 487, an outbreak of infectious keratoconjunctivitis, i.e., “pink eye,” reduced the population by approximately 60% (Meagher et al. 1992). Although the temporary vision impairment caused by the infection is rarely fatal for domestic sheep that are fenced and fed, it can result in death for a wild animal that must find its forage in steep places.

During a May 2009 aerial survey Montana Fish, Wildlife, and Parks counted 349 sheep on the northern range. Based on the portion of the population that was likely undetected during the survey, the total 2009 population was estimated at 350 to 400. In the park, sheep were observed in locations from Mount Everts to Mammoth Hot Springs, from Mount Norris to Tower Junction, and from Black Canyon to Barronette Peak. Outside the park, sheep were observed in these areas: Point of Rocks, Tom Miner basin, Yankee Jim Canyon to LaDuke, Travertine/Bear Creek to Deckard Flats, and Beattie Gulch to Cinnabar Mountain.

Most of the sheep migrate seasonally, though distances vary and some simply enlarge their winter range for use during the summer. Most winter ranges are lower-elevation areas along the Yellowstone, Lamar, and Gardner rivers.

Mount Everts is the most heavily used winter range, and Bighorn sheep congregate on this area for the rut in November and December. Rams that use the Mount Everts winter range include both year-round residents and migratory animals, some of which travel more than 30 km southwest to the Gallatin Mountains in the summer. The McMinn ewe group occupies the Mount Everts range year-round, the Rattlesnake Butte ewe group uses the area for two to three weeks during the rut and the spring green-up, and the Mount Washburn ewe group uses the area from November until late May (Ostovar 1998). Some movement north out of the park occurs year-round.

ECOLOGY

Habitat

Bighorn sheep are habitat specialists that prefer steep, rocky areas with high horizontal visibility and escape terrain—areas with slopes $>27^\circ$ and occasional rock outcroppings that provide protection from predators and disturbances (Gudorf et al. 1996). Core habitat is likely to be within 980 feet (300 m) of escape terrain or within 3,280 feet (1,000 m) if bordered by escape terrain on at least two sides. Other parameters for suitable habitat are aspect, distance to perennial water sources, natural and manmade barriers to migration, and proximity to human activities and domestic animals (Gudorf et al. 1996; Johnson and Swift 2000; Schoenecker 2004). Sheep prefer areas that have open vegetation, where they can visually detect predators and maintain contact with members of their herd, and that are within 2.0 miles (3.2 km) of perennial water sources (Johnson et al. 2000). Habitats that restrict routine bighorn movement by natural barriers (e.g., large or fast moving rivers, lakes, and dense vegetation fences) or manmade barriers (e.g., roads, canals, housing developments, and reservoirs) are considered less suitable. Areas with development or high human use are considered unsuitable, though a 490 feet (150 m) buffer may suffice in low to moderate use areas (Johnson and Swift 2000). Buffer zones of 11–18 miles (17–29 km) between bighorn sheep and domestic animals have prevented contact and disease transmission (Schoenecker 2004).

Bighorn sheep typically migrate to multiple seasonal ranges, making several predictable movements throughout the year. Annual movement patterns are learned from older individuals and passed on through generations. Seasonal ranges are typically classified as winter, spring, and lambing, however rams are known to use up to seven ranges and ewes often use four. Rams and ewes remain apart for most of the year, but join for the rut in November and December (Geist 1971). Bighorn sheep seasonal range characteristics vary among populations and available habitat. However, lambing habitat is typically southern aspect, broken, rugged cliffs. Suitable winter ranges are



southern aspects of slopes or windswept ridges with snow accumulations <10 inches (25 cm). Snowpack exceeding 10 inches (25 cm) makes moving and accessing forage difficult (Gudorf et al. 1996; Schoenecker 2004).

Bighorn Canyon National Recreation Area: Kissell et al. (1996) found that sheep are typically found at lower elevations (<4920 feet, 1500 m) of Bighorn Canyon NRA and on less steep, eastern aspect slopes (<31°). Bighorn Canyon NRA is considered semi-arid in the Dry Head area and sub-alpine at higher elevations in the Pryor Mountains. Vegetation communities include desert shrubland, juniper woodland, mountain mahogany woodland, sagebrush steppe, basin grassland, juniper/mountain mahogany woodland, riparian, and coniferous woodland (Schoenecker 2004). The sheep show preference for mountain mahogany habitats and riparian areas over juniper habitat in the summer and grassland habitat in the winter in addition to mixed shrub, sagebrush, forest habitats year-round (Singer and Gudorf 1999). Sheep appear to use grassland habitat in proportion to its availability during the summer and juniper habitat in proportion to its availability during the winter, which may suggest a reliance on juniper to survive the season.

The diet of Bighorn Canyon sheep consists mainly of browse year-round, including winterfat (*Krascheninnikovia lanata*) and curlleaf mountain mahogany (*Cercocarpus ledifolius*). The most common grasses consumed are wheatgrass (*Agropyron* spp.) and needle-and-thread (*Stipa* spp.). Grasses (*Agropyron* spp., *Poa* spp., *Stipa* spp., and *Festuca idahoensis*) comprise 54–65% of the spring diet and 41.5% of the summer diet (Kissell et al. 1996). The sheep consume few forbs although Kissell et al. (1996) found that 14.1% of their spring diet consisted of *Erysimum* spp./ *Lithospermum* spp., *Phlox hoodii*, *Erigeron* spp., and unidentified forbs. The selenium that sheep derive from plants prevents “white muscle disease” and may increase the survivorship of lambs by strengthening immune systems. Selenium levels are acceptable but low in Bighorn Canyon NRA and the availability of nutrients may influence sheep distribution (Schoenecker 2004).

Wild horses (*Equus caballus*) on the Pryor Mountain Wild Horse Management Range, which includes the west-central part of Bighorn Canyon NRA and adjacent BLM land, do not appear to compete with bighorn sheep for habitat. Though the two species have considerable overlap in spring and summer diet (*Agropyron* spp. and *Stipa* spp.), there are spatial and habitat separations between sheep and horses (Schoenecker 2004). Mule deer (*Odocoileus hemionus*) do not appear to compete with or have a negative affect on bighorn sheep. Habitat overlap with mule deer is more likely in the winter, but at present the sheep use steeper slopes than deer. The most likely forage competition between deer and sheep would be for mountain mahogany, because it dominates both species’ diets (Kissell et al. 1996).

Yellowstone National Park: Mount Everts, the area most heavily used by bighorn sheep in Yellowstone, is relatively warm compared to the rest of the park and has windblown southwest facing slopes with little snow accumulation. Barmore (2003) found that most northern Yellowstone bighorn sheep at lower elevations fed in areas with <3 inches (8 cm) of snow; <5% fed in areas with 6-12 inches (15-30 cm). At higher elevations, 25-30% of sheep fed in snow >15 cm deep between November and March. In March, most sheep moved to feed in areas with little snow accumulation until May.

The Mount Everts winter range consists primarily of Idaho fescue (*Festuca idahoensis*) bluebunch wheatgrass (*Elymus spicatum*), and sage (Ostovar 1998). In higher elevations and drainages, scattered woodlands are present, including several Douglas fir forests. Forest habitats related to summer ranges and migration routes are typically subalpine-fir (*Abies lasiocarpa*), Engelmann spruce, whitebark pine. Summer ranges above 10,800 feet (3,300 m) are usually classified as alpine tundra habitat, with common grass species of sheep fescue (*Festuca ovina*), timberland bluegrass (*Poa rupicola*), Cusick’s bluegrass (*Poa cusickii*), Sandberg’s bluegrass (*Poa sandbergii*). Common alpine tundra forb species are silvery lupine (*Lupinus argenteus*), artichoke sandwort (*Arenaria obtusiloba*) and lance leaf stonecrop (*Sedum lanceolatum*) (Ostovar 1998).

The sheep have shown preference for ridge tops and steep south- and west-facing slopes, suggesting that escape terrain was important to habitat selection. During the 1960s, sheep grazed year-round at higher elevations, primarily on xeric grassland, dominated by bluebunch wheatgrass, Sandberg bluegrass, junegrass (*Koeleria macrantha*), needle-and-thread, and Idaho fescue (Barmore 2003). During the winter at lower elevations, sheep appeared to prefer mesic grassland dominated by Idaho fescue, junegrass, bluegrasses, needlegrasses, and basin wild rye (*Elymus cinereus*). Sheep used xeric grasslands less and sagebrush habitats more in the late 1980s (Singer and Norland 1994). Winter diets were dominated by grasses (*A. spicatum*, *F. idahoensis*, *Poa* spp., *K. macrantha*, *Stipa comata*), which comprised 58-66% of the seasonal diet. The remainder of the diet was 22–33% shrubs (*Ceratoids lanata*, *A. tridentate* and *A. frigida*, *Chrusothamnus* spp.), 7–17% forbs, 1–5% sedges, and 0–2% conifers.

The Mount Everts winter range is along a migration route for elk (*Cervus elaphus*), mule deer, pronghorn (*Antilocapra americana*), and bison (*Bison bison*). Elk and bighorn sheep had high diet and habitat overlaps (diet: 0.62-0.73; habitat 0.48-0.78) in the 1960s and 1980s (Singer and Norland 1994). Although the bighorn sheep population declined substantially in the early 1980s because of the *Chlamydia* epizootic while the elk population was growing, the increasing overlap was



primarily a result of the bighorn sheep broadening their diet and habitat ranges during that time, and increasing their use of mesic grasslands and sagebrush. Bighorn sheep's increasing use of tall shrubs, which are not a preferred food, may reflect competition with elk (Singer and Norland 1994). During 1982-1995 this competition may have limited the ability of the sheep population to rebound from the disease outbreak (Ostovar and Irby 1998). However, from 1998–2005, the elk population decreased by 50% while the sheep population increased 7% annually, and reduced competition with elk could have an effect on lamb recruitment and sheep population growth.

Reproduction

Ewes have one 28-day estrus cycle a year with a 2–3 day receptive period (Krausman and Bowyer 2003). Most females begin breeding at 2–3 years; rams typically breed at 7–8 years and only mate for a few years. Bighorn sheep are polygamous. During the estrus cycle, rams will search for ewes in estrus and attempt to chase less dominant rams away from receptive ewes. Dominant, large horned rams will typically guard or tend ewes during estrus, which establishes exclusive breeding for the period. Adult rams are dominant and treat all other individuals as females. Dominance is established by horn size, age, and body size. If horns are of equal size, dominance is determined by a fight; otherwise the rams assume dominant-subordinate interactions. Only 10-25% of the rams in a typical population may breed, and 60% of the breeding rams are those with the largest horns (Singer and Gudorf 1999).

Lambing occurs in late April or May on the steepest slopes, where ewes spend 1-2 days to give birth. Ewes with lambs require contiguous escape terrain because of their increased vulnerability. Young lambs also benefit from thermal cover and suitable habitat includes slopes 27-85° that are not north-facing. Lambing habitat should also be within 0.6 miles (1 km) of water because lactating ewes require continuous water sources (Gudorf et al. 1996). Lambs are able to travel with their mothers within 24 hours of birth and are weaned within 3-5 months. Ewes usually produce a single lamb a year until old age or death (Krausman and Boyer 2003). In the Bighorn Canyon herd from 2000–2003, the pregnancy rate of ewes was 73% and the lambing rate was 72% (Schoenecker 2004).

Population Dynamics and Survival

Though the sex ratio of bighorn sheep at birth is 1:1, ewes outnumber rams as adults (Geist 1971). Population dynamics are strongly affected by year-to-year variations in lamb and yearling survival, primarily because adult survival is not greatly influenced by changes in population density. Low recruitment, due to factors independent of density, limits the ability of high-elevation populations to respond to severe population decreases caused by disease epizootics, severe stochastic weather events, or removals

(Buechner 1960, Stevens and Goodson 1993).

Lamb mortality is generally high, but decreases as sheep become yearlings. Rams age 3-5 years have death rates ranging from 3-14% (Krausman and Boyer 2003). This rate increases to at least 60% by the time older, dominant rams reach 15 years. Mortality data on ewes is limited because of the difficulty in determining age by horn growth. However, dominant rams and fertile ewes have shorter life expectancies, which may be related to the costs of reproduction (Geist 1971).

Bighorn Canyon National Recreation Area: The population structure of the Bighorn Canyon herd averaged 52 rams:100 ewes from 1993–1996 (Kissell et al. 1996). This ratio declined, then increased from 39 rams:100 ewes in 2000, to 58 rams:100 ewes in 2001, to 69 rams:100 ewes in 2002. The average annual survival rate of adult bighorn sheep was 90% from 2000-2003 (Schoenecker 2004). Survivorship of lambs past one year of age was 44% in 2002, 23% higher than in 2001, which may have been because the low water levels in Bighorn Lake that year resulted in limited recreational use or other human disturbances, and little access for large predators. Sheep were seen on the lake bottom throughout the summer of 2002 (Schoenecker 2004).

The population decline in 1995-1996 was likely due to pasteurellosis (*Mannheimia haemolytica*), which causes bronchopneumonia. Pasteurellosis is contagious among wild and domestic ruminants and has caused major die-offs in bighorn sheep populations. Signs include serous nasal discharge and infrequent coughing. Most adults develop immunity, but lambs continue to be susceptible for two years after the initial outbreak, causing lamb survival to be very low. If pasteurellosis is a chronic problem, lambs will typically die at four to eight weeks (28-56 days). A vaccine does not exist at this time (Schoenecker 2004).

During a 2000-2003 study in which 13 radio-collared sheep died, 77% of the mortalities occurred during the winter. Six deaths were caused by predation (four by mountain lions, one by a black bear, and one coyote killed a ewe that had had a broken leg for five months), one death from illness or disease, three from unknown causes or presumed old age, and three from capture myopathy. Mountain lion predation on sheep is an individual, learned behavior (Schoenecker 2004). One ram was found in 2005 under the ice of Bighorn Lake.

In recent years, MFWP has issued up to four licenses for “legal” rams (those with horns that form at least 3/4 of a circle from the side) in an area of the Pryor Mountains that includes Bighorn Canyon, BLM, and USFS land.

Yellowstone National Park: The northern Yellowstone bighorn sheep population has had an annual mean of 20 lambs:100 ewes since 1992. Recruitment decreased during 1997-1998, when a severe winter led to substantial ungulate winterkill and likely contributed to high lamb mortality the following spring. But the population growth



rate has been relatively stable to slightly increasing since 1995. Recruitment increased to an average of 29 lambs:100 ewes during 1999 to 2009. The mean survival rate for 18 sheep on the Mount Everts winter range was 0.89 (range = 0.83 to 0.94) during 1998 to 2002. The 349 sheep counted in the 2009 survey included 194 ewes, 51 lambs, and 104 rams, with a ratio of 26 lambs:100 ewes.

Predation by wolves (*Canis lupus*) does not appear to be limiting population growth (White et al. 2007) and there has been no sign of *Chlamydia* in the sheep since the 1981–1982 outbreak, suggesting that other factors have been involved. Antibody reactions were present in bighorn sheep on the Mount Everts winter range in 1997 for bovine respiratory syncytial virus, parainfluenza-3, and leptospirosis 8 serovars. Lamb deaths caused by pneumonia, which can be a factor in low recruitment, have been reported north of the park. Lungworm (e.g., *Protostrongylus* spp.) may be a predisposing factor to respiratory disease; however, it has not been linked to higher rates of lamb pneumonia or as a significant factor depressing the long-term status of the northern Yellowstone population. Although 29–88% of sheep wintering near LaDuke Hot Springs had lungworm during 2002–2003, no lungworm was found on sheep wintering near Cinnabar Mountain in 2002. In 2004, 49% of the sheep wintering on Mount Everts had lungworm infection.

Bighorn sheep in Yellowstone are occasionally preyed upon by coyotes (*Canis latrans*), bobcats (*F. rufus*), black bears (*U. americanus*), grizzly bears, wolves, mountain lions, and golden eagles. Predation and predator presence on Mount Everts and elsewhere in northern Yellowstone is correlated winter severity, but predator density is lower on bighorn sheep's higher elevation summer ranges (Ostovar 1998). Of the 12 mortalities in 18 bighorn sheep on the Mount Everts range that were radio-collared during 1998–2005, three were caused by mountain lions, one by an unknown predator, one by winterkill, one by a lightning strike, one by poaching on Deckard flats, and six from unknown causes (White et al. 2007).

STATUS AND THREATS IN THE GREATER YELLOWSTONE AREA

Habitat loss and disease are the major threats for bighorn sheep populations. The GYA sheep populations are small and isolated, increasing the vulnerability of a population to inbreeding and disease (Meagher et al. 1992). Habitat fragmentation, caused in part by human development, has prevented use of historical migration routes. Vegetation encroachment as a result of fire suppression reduces horizontal visibility and available sheep habitat (Singer and Gudorf 1999). Population growth can be affected by the loss of traditional lambing areas and movement corridors, which decreases genetic exchange and lamb recruitment

(Meagher et al. 1992). Sheep are poor dispersers; reintroduced populations can have difficulty locating historical feeding grounds and travel routes may have become overgrown (Singer and Gudorf 1994).

Diseases passed on by domestic animals can cause major die-offs in sheep populations. Buffer zones between bighorn sheep habitat and domestic sheep grazing allotments can prevent disease transmission. Populations greater than 300 are better able to survive and recover from an outbreak (Schoenecker 2004).

Legal rams, which are generally the most dominant rams with breeding superiority, are subject to harvest from the Bighorn Canyon herd and west of GTNP; however, only a small number of permits is issued each year and trophy hunting does not appear to affect recruitment, ewe or lamb survival rates (Schoenecker 2004). In GTNP, portions of Static Peak, Mount Hunt and Prospector Peak are closed during the winter to protect sheep from disturbance from skiers, but there is concern about the increase in backcountry skiing on Bridger-Teton National Forest outside Jackson.

The core sub-population of northern Yellowstone bighorn sheep that winters on the Mount Everts range remains at risk of local extirpation because isolation, low abundance, and recruitment have increased its vulnerability to severe winter weather, drought, and disease. In 2002, the National Research Council concluded in its congressionally directed, 3-year review of ungulate management on the northern range of Yellowstone National Park that bighorn sheep may be responding adversely to competition with elk, mule deer, and bison during severe winters. A study conducted by Montana State University during 1968–1998 to evaluate human-caused disturbances and the potential impact of road realignment in Yellowstone on the bighorn sheep that use winter range on Mount Everts found that they were most likely to be disturbed by helicopter flights, motorized vehicles, humans on foot, and predators. Some of the bighorn sheep in Yellowstone appear habituated to human activity, but the McMinn Bench group was most likely to be affected because it crosses the Mammoth–Gardiner road several times during its migration to spring lambing areas (Ostovar 1998).

MANAGEMENT ACTIVITIES

Through monitoring, habitat assessment, and cooperation with other state and federal agencies responsible for land and wildlife management, park managers work to maintain bighorn sheep populations in greater Yellowstone that experience minimal human interference with their natural population dynamics and distribution.

Bighorn Canyon National Recreation Area:

Following a 2000–2003 study by the U.S. Geological Survey, Bighorn Canyon NRA has continued to monitor



the bighorn sheep population on a weekly basis. Habitat assessments using GIS were conducted to determine appropriate locations for fire treatments and mechanical thinning to improve otherwise suitable habitat (Singer and Gudorf 1999). Habitat improvement projects in juniper woodland and sagebrush steppe area are highest priorities because they provide the most benefit to bighorns and have long-lasting effects (Schoenecker 2004). WGFD translocated a total of 40 sheep to neighboring Devil Canyon in 2004 and 2006 in an effort to increase the Devil Canyon herd to 200, and it is hoped that these sheep may eventually interbreed with the Bighorn Canyon herd to increase the viability of both populations.

Yellowstone National Park: The Park Service conducts annual spring and summer aerial surveys to monitor the northern Yellowstone bighorn sheep populations in cooperation with the Montana Department of Fish, Wildlife, and Parks, Wyoming Game and Fish Department, and the U.S. Forest Service.

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